

THE LOCKING OF THE DARLING RIVER.

A BRIEF REVIEW.

*(A paper read before the Sydney University Engineering Society,
December 8th, 1897, by William Poole, jun., Assoc. M. Inst., C.E.*

To supplement the paper by Mr. E. A. Amphlett, B.E., on the design and construction of the Bourke Lock and Weir, the author now submits the following brief review of the physical conditions of the Darling River, the difficulties to be overcome, and the various schemes proposed for overcoming them up to the present time.

PHYSICAL CONDITIONS.

The Darling River has its catchment area on the Western slope of the Great Dividing Range, partly in the Northern portion of New South Wales, and partly in the Southern portion of Queensland.

The river is formed by the confluence of the M'Intyre and the Dumaresq Rivers, and is afterwards joined by the Gwydir, Namoi, Castlereagh, Macquarie, Bogan, Balooone, and Warrego Rivers; but these last named rivers, with the exception of the Namoi, contribute very little water, except after heavy falls of rain.

From the confluence of the M'Intyre and Dumaresq Rivers between Goondiwindi and Mungindi the river is known as the M'Intyre, thence to Brewarrina as the Barwon, and below Brewarrina as the Darling River.

The river has been navigated to Mungindi on the Queensland border, a distance of 1,400 miles from Wenworth, where it joins the Murray River. From Wentworth to Murray mouth is about 600 miles, so that the river is navigable, under favourable conditions, for the great distance of 2000 miles.

The Darling River has a deep, narrow, and in places very tortuous channel. The ratio of increase in length due to winding is about $2\frac{1}{4}$ to 1. The channel is generally 300 to 400 feet wide between the banks, and maintain a remarkable uniformity in width from Walgett to Wentworth, a distance of 1190 miles. Between Walgett and Wentworth there is a fall of 321 feet, or an average of 3.25 inches per mile.

Fall of Darling River between Walgett and Wentworth* :—

STATION.	DISTANCE FROM PREVIOUS STAT'N	FALL IN FEET.	RATE PER MILE IN INCHES.
Walgett	—	—	—
Bourke	290	84.48	3.49
Wilcannia	394	105.18	3.20
Wentworth	505	131.77	3.12

There is thus a remarkable evenness in the general rate of fall, though there are local variations in these average rates.

The banks are composed of friable clay and loose silt. The bed consists of fine sand and silt, with rocky bars at intervals, varying from soft sandstones to very hard quartzites, and consisting either of a single bar or a series of bars, and detached masses extending along the river bed for several miles. The rocky patches are generally in proximity to the bed loam country, which is of older geological age than the dark clay plains which are of more recent river alluvial formation.

The total catchment area of the Darling River is 256,000 square miles, but from only 105,000 square miles of this area is any water received by the river system. The mean annual rainfall over the contributing area is 23 inches per year, but the rainfall is very irregular. Sometimes there are periods of several years during which the river is open for navigation for nearly the whole time, but there are also periods extending over several years during which navigation is only possible for a few weeks at a stretch ; while on several occasions the river has stopped running altogether.* Under favourable conditions the river is navigated from Wentworth to Collarindabri, a distance of 1290 miles, the remaining portion to Unugindi being too much obstructed by snags and overhanging trees.

Along the whole course of the Darling there are numerous ana-branches and subsidiary channels which usually commence to run when the river is about two-thirds bank high. The channels are of

* See Report Utilisation of Darling River, 1892.

† See River Height Diagrams in Report Utilisation of Darling, 1892.

various sizes and lengths, and except where hereafter stated the water again returns from them to the main river channel. There is no place along the whole course of the Darling where such channels do not exist either on one side of the river or the other; often they occur on both sides. In some cases longer anabranches enclose one or more shorter channels.

Near Menindie there is a number of large lakes, filled during high river, and empty again as the river falls low. The outflow from which is so large as to render the river navigable down to Wentworth, when it would not otherwise be so.

A short distance above Wilcannia a large effluent channel known as the "Great Talwalka," breaks out, joining the river again below Menindie; most of the water is, however, diverted by a large dam into a series of large lakes about 50 miles east of Menindie. The water does not again return to the river. Below Menindie another large effluent stream "The Great Anabranche of the Darling" breaks out. This channel feeds a large series of lakes on the right hand side of the Darling, and it is only after very heavy floods that a small portion of this effluent water enters the Murray between Wentworth and the South Australian border.

SCHMES FOR IMPROVEMENT OF THE RIVER.

The great irregularities in the flow of the river and the long periods during which the river may be closed, were soon found to be a serious hindrance to its use as a commercial highway.

In 1883 a syndicate obtained the services of Mr. George Gordon, M. Inst. C.E., who considered that the river could be made permanently navigable, and recommended a series of locks to weirs between Wentworth and Wilcannia. The class of work recommended was a lock 200 feet long by 18 feet wide, with a lift of 4 to 6 feet, and a weir consisting partly of a navigable pass and partly of a fixed weir. It was proposed to construct these works in the bed of the river.

In 1888 the subject was taken up by the Harbours and Rivers Department, and in 1890 the Engineer-in-Chief for Harbours and Rivers recommended a series of locks and weirs between Bourke and Wentworth. The locks proposed were to be 132 feet long, by 33 feet wide and having a lift of 10 feet, placed in cuttings across narrow necks of bends of the river. The weirs were to be fixed and placed in the bends between the inlet and outlet ends of the lock cuttings. It was recommended that an experimental weir be first built about 40 miles above Wentworth.

In 1892 the dealing with this matter was transferred to the newly formed Water Conservation Branch, and in August of that year the author was sent to Wilcannia to select a site for an experimental lock and weir, such that the weir might also serve to divert surplus water into the Great Talywalka. The investigations proved unfavourable to this project, and showed (a) That no suitable site with a good foundation could be found in the required locality ; (b) That the subsidiary channels and low land in the bends of the river would be flooded before water could be diverted into the Talywalka, while the height of the weir required to divert water was upwards of 25 feet, which, upon purely engineering grounds, was inadmissible.

In December, 1892, the Chief Engineer for Water Conservation recommended a series of locks and weirs from Walgett to Wentworth. The locks to be 200 feet long, and not less than 37 feet wide, with a lift of about 6 to 8 feet. The weirs to be of moveable shutters on the "Channoine" system. Both lock and weir to be placed side by side in a straight reach of the river.

In December, 1893, the matter was again taken up, and Messrs. Rygate and McTaggart were sent to select lock and weir sites between Walgett and Brewarrina, while the section between Wilcannia and Menindie was assigned to the author. This survey was almost completed when further work was prevented by a flood.

In January, 1895, the author was sent to Bourke to select a site for an experimental lock and weir. The sight selected, recommended and approved was about three miles below Bourke, and the Bourke lock and weir has since been built at this site, as described in Mr. Amphlett's paper.

Bourke was the best situated centre for the delivery of cement, iron, timber, etc., required in the construction of the proposed works.

The points to be considered in selecting the site for the Bourke Lock and Weir were (a) A good site from an engineering point of view ; (b) A site below the town of Bourke, so that a large and deep body of water should be conserved, which would facilitate shipping, and be available for the town water supply, and also for a proposed irrigation settlement at North Bourke (not proceeded with since the establishment of the irrigation settlement at Pera Bore, about nine miles from Bourke). After the survey for the Bourke weir site was completed, a longitudinal section was taken of the river bed from Brewarrina to Bourke. This latter work disclosed considerable irregularities in the low river slope of the flowing stream, together with a deep hole above Vincent's rocks, between 25 and 30 miles long.

A series of lock sites were then selected between Bourke and Brewarrina. The outcome of this survey was the series of locks and weirs proposed by the Chief Engineer, and submitted to the Public Works Committee for report.

The works proposed by Mr. Gordon are unsuitable, inasmuch as the width of the lock proposed would exclude all the steamers and all but a few very small barges then employed on the river. The physical conditions of the river will not permit of horse towage for smaller barges.

There are three very serious objections to the scheme recommended in 1890:—

(i.) The making of a cutting across the neck of a bend would inevitably lead to a new channel being formed across the bend, and round the side of the lock, whilst an embankment from the weir to the lock would only cause the channel to be cut somewhere else. It has been ascertained by trial borings that the land in the river bends is always composed of fine silty material down to and below the river bed level. A high solid weir would cause a surcharge on the up-stream side, and the water, in a rising flood, would flow across the bend and fall into the outlet channel with an amount rather more than this surcharge. A secondary, and, in short, main channel would consequently soon be cut back across the bend. A solid weir as proposed would retain at low water a head of 10 feet of water, and would be at least 16 feet above the bed of the river.* It was estimated that a weir of this class would raise the flood level $1\frac{1}{2}$ inches.† The critical period would be not so much in full flood as when the water is just commencing to break across the bends. The surcharge at this stage would be considerably more than that mentioned above. The wing-embankments and other protective works would require to be so built as not to prevent the lateral escape of flood water, which, in extreme flood would be impossible, but to spread it over as wide an area as possible.

(ii.) When the river is about half bank high the current over the crest of the weir would be at its maximum velocity. The banks and bed of the river, which are of a very friable nature, would, for a considerable distance below the weir, require to be protected, both from the normal current and also from the back eddies which are liable to be formed. The oscillation set up in the water below weirs causes a lapping motion which is very destructive to unprotected banks. From investigation it is found that good foundations for a

* See Report, Locking Darling River, 1890.

† See evidence of Engineer-in-Chief for Public Works before Public Works Committee. Report, Construction of Locks and Weirs on Darling River.

weir can rarely be obtained at a bend, the bed of the river in such places being generally excavated into a series of deep holes. A bend has also a general tendency to widen its average radius.

(iii). A fixed weir would necessitate the lock being always in use, except in flood time.

The scheme recommended in 1892 and again in 1895, has the advantage of reducing all risks of failure to a minimum. A folding or moveable weir admits of the best possible amount of obstruction to the passage of the water in the river channel, since, as soon as the flow of water is sufficient to admit of navigation under natural conditions, the shutters of the weir may be lowered, thus doing away with objections (ii.) and (iii.) of the 1890 scheme. By placing the lock in the bed of the river objection (i.) is removed. The objection to this scheme is that during high river the slack water in and behind the lock chamber will cause a large amount of silt to be deposited in it and on the down stream side. It has been urged that floating debris would damage the light structure of a moveable weir. The author has been on the river at all stages from very low to moderate flood. At such stages at which the moveable weir would be in operation there is no floating debris of a more serious nature than twigs and leaves; indeed, even in high river, there is but little debris on account of the Darling being so far removed from the source of floating timber. It is often urged that a fixed weir causes the bed of the river to silt up on the upstream side of the weir. Although this is undoubtedly true in the case of most rivers, there is strong reason to believe that in the case of the Darling it would not be so. The investigations of the author have shown that large deep holes exist above all the rocky bars, or series of bars, examined by him. These rocky bars are, in fact, natural weirs ranging up to eleven feet high. A deep hole exists above all the following bars, viz., Brewarrina Falls, Vincent's Rocks, hard bar just below Bourke wharf, Wilcannia Rocks, Eight Mile Rocks, Culpaulin Rocks, hard bar at Uulyevery, Rocky Water Holes, Christmas Rocks. Where there is a series of rocky patches in quick succession, a deep hole may only exist above the uppermost bar of the series, *e.g.* at Brewarrina Falls and Vincent's Rocks. The non-deposition of silt above these natural weirs is probably due to the very fine state of the sand which travels along the river bed, the degree of fineness being such that in high river the current is able to carry most of it in suspension. There is no gravel of any description in the river bed.

In conclusion the author would say that the successful building and operation of the Bourke Lock and Weir demonstrates the practicability of such works.